

PERIODICITY OF EXTINCTION: A 1988 UPDATE; J. John Sepkoski, Jr.,  
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The hypothesis that events of mass extinction recur periodically at approximately 26-myr intervals is an empirical claim based on analysis of data from the fossil record. The hypothesis has become closely linked with catastrophism because (1) several events in the periodic series are associated with evidence of extraterrestrial impacts (e.g., the K-T mass extinction), and (2) terrestrial forcing mechanisms with long, periodic recurrences are not easily conceived. Astronomical mechanisms that have been hypothesized include undetected solar companions ("Nemesis," "Planet X") and solar oscillation about the galactic plane, which induce comet showers and result in impacts on Earth at regular intervals. Because these mechanisms are speculative, they have been the subject of considerable controversy, as has the hypothesis of periodicity of extinction. Critics have questioned the data base for analyses (originally extinction times of taxonomic families), the statistical treatment of the data, and the chronometric time scales used in the tests.

In response to criticisms and uncertainties, I have been developing a data base on times of extinction of marine animal genera. The full data set, compiled from the primary paleontologic literature, contains information on more than 30,000 fossil genera. Times of extinction of 75% have been resolved to the level of stratigraphic stage or substage, permitting extinction metrics to be computed for intervals of about 5 myr duration over the last 270 myr. These metrics permit much easier distinction between extinction events and background extinction than did previous data.

Figure 1 displays a time series with 49 sample points for the per-genus extinction rate from the Late Permian to the Recent. Eleven peaks are evident, but two (the Carnian between the Tatarian and upper Norian, and the Bajocian between the Pliensbachian and the upper Tithonian) are not distinct from background. Of the remaining nine peaks, all but two (the Aptian and Middle Miocene) have been recognized in detailed paleontologic studies of species in local stratigraphic sequences. The fit of the 26-myr periodicity to these nine peaks is excellent: the standard deviation of differences between expected and observed positions of peaks is less than 10% of period length (with more than 5% contributed by the upper Norian event) and only about 3% for the four events in the well-dated last 100 myr of the time series. Note that only one gap remains in the periodic sequence: no event is evident in the Middle Jurassic (although perhaps the Bajocian "peak" is a candidate).

An unexpected pattern in the data is the uniformity of magnitude of many of the periodic extinction events. Six fall in the range of 10-15% generic extinction and are indistinguishable within the resolution of the data. Based on rarefaction estimates, these magnitudes of generic extinction translate into 25-35% species extinction. The three other mass extinctions are much larger and appear almost as outliers; these are the Upper Permian event (78-84% generic extinction, 93-95% estimated species extinction), the upper Norian event (36-47% generic extinction, 63-75% species extinction), and the Maestrichtian event (also 36-47% generic extinction, 63-75% species extinction). These observations suggest that the sequence of extinction events might be the result of two sets of mechanisms: a periodic forcing that normally induces

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only moderate amounts of extinction, and independent incidents or catastrophes that, when coincident with the periodic forcing, amplify its signal and produce major mass extinctions.

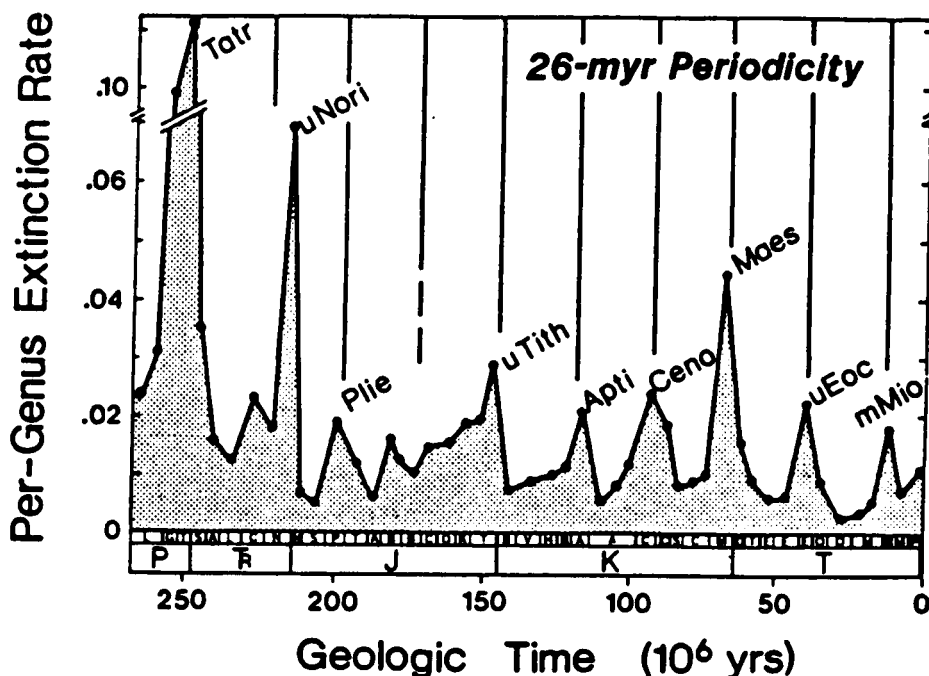


Figure 1. Per-genus rate of extinction for 11,000 marine animal genera from the Late Permian to the Recent. Units are in extinctions per genus-million years. The vertical lines show the fit of the 26-my periodicity to the extinction peaks. Labels on the peaks are Tatr = Tatarian (last "stage" of the Upper Permian), uNori = upper Norian (including the Rhaetian), Plie = Pliensbachian, uTith = upper Tithonian, Apti = Aptian, Maes = Maestrichtian ("K-T" event), uEoc = Upper Eocene, and mMio = Middle Miocene. Geologic systems and stages are indicated by standard symbols and initial letters, respectively, along the abscissa.